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PAPER

Improving Public Health Readiness for Sea Level Rise: A New Initiative in Coastal Virginia

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ABSTRACT

Sea level has been rising around the world, and in recent decades, the rate has been accelerating. Because rising seas have the potential to directly or indirectly affect the health of vast numbers of coastal communities and inhabitants, public health agencies and professionals—in conjunction with other fields—have a pivotal role to play in helping to protect populations, reduce and prevent health impacts, and foster resilience. This article discusses a novel effort that has been undertaken in Coastal Virginia to help prepare the next generation of public health professionals to grapple with sea level rise issues. The effort grew out of discussions of the importance of public health issues that took place through the Hampton Roads Sea Level Rise Preparedness and Resilience Intergovernmental Pilot Project. The new training effort focuses on public health graduate level training and incorporates both classroom and practice-based components. Though still in its early stages, the sea level rise and public health training effort has already achieved significant successes and continues to grow. The article begins by examining sea level rise as a public health issue. This is followed by a discussion of the new public health training initiative in Coastal Virginia. The article closes by exploring future directions.

Keywords: sea level rise, public health, resilience, intergovernmental pilot project

Introduction

It is now widely understood that sea level is rising around the world. Over the past century, global mean sea level has already risen approximately 8 inches (Levy & Patz, 2015). But this represents a global average; the sea is actually rising "much more in some places than in others" (Sobel, 2014). In the Miami area, for example, sea level is estimated to have increased by significantly more than the global average, rising about a foot in the past 100 years. Similar increases have been experienced in New York and Charleston (New York City Panel on Climate Change, 2015; City of Charleston, 2015). Furthermore, the rate of sea level rise has not remained steady; rather, there is strong evidence that it is speeding up significantly (NOAA, 2017a; Nerem et al., 2018). For example, it has been reported that the sea has risen nearly 4 inches in Miami in just the past two decades (McNoldy, 2015).

With the scope and urgency of the problem of global sea level rise becoming more apparent every year, a host of disciplines and professions are now working to better understand this emerging threat and its implications. From biology, ecology, and environmental science to ocean science, coastal engineering, and underwater robotics, a variety of fields are helping to further illuminate the dynamics of the problem, identify current and future challenges, and begin to fashion effective responses.

Because some of the most significant impacts of rising sea level are those directly or indirectly affecting human health, another field that has a pivotal role to play is public health. The field of public health "promotes and protects the health of people and the communities where they live, learn, work and play" (APHA, 2017). Whereas a medical doctor can be thought of mainly as treating and healing sick individuals, public health deals with the health of entire populations (APHA, 2017). "These populations can be as small as a local neighborhood, or as big as an entire country or region of the world" (CDC Foundation, 2017).

The need for a major public health role in addressing sea level rise stems from the fact that rising seas have the potential to affect vast numbers of coastal communities and inhabitants. From a global perspective, "eight of the top ten largest cities in the world are located by the coast" (UN, 2016). In the U.S. context, approximately 40% of the nation's population resides

in counties directly on the shoreline (NOAA, 2017b). In other words, rising seas have the potential to directly or indirectly impact the health of millions of people.

The health impacts of sea level rise are expected to grow in the coming decades, creating significant challenges for local and state public health departments; regional, national and international health agencies; and other components of the public health field. As such, it will be vital for public health professionals to be involved and prepared. This article discusses a novel effort that has been undertaken to help prepare "the next generation of public health professionals to grapple with sea-level rise issues" (IPP, 2016). Launched in Coastal Virginia in 2015 and focusing on public health graduate level training, the effort is still in its early stages. But it has already achieved significant successes and continues to grow. The article begins by examining sea level rise as a public health issue. This is followed by a discussion of the new public health training initiative in Coastal Virginia. The article closes by exploring future directions.

Rising Seas and Public Health

Sea level rise has the potential to directly or indirectly affect the health of coastal populations in a multiplicity of ways. Rising seas can result in increased salinity of estuaries and aquifers, harming vital drinking water supplies upon which communities depend. Changes in salinity can also foster the growth of microorganisms, including those associated with human illness. In addition, rising seas can raise water tables and greatly exacerbate drainage problems. Pools of standing water can accumulate, facilitating the growth of mosquito populations and increasing the risk of disease spread. Sea level rise is also associated with increases in the frequency and severity of flooding. Indeed, in recent decades, there has been a dramatic increase in "minor" flooding events (also sometimes described as "nuisance" flooding) on all three U.S. coasts—Atlantic, Pacific, Gulf (NOAA, 2014a). This phenomenon is clearly illustrated by the experience of Atlantic City, New Jersey, where the average number of flood days has gone from 3.1 per year in the period between 1957 and 1963 to 24.6 a year in the period between 2007 and 2013. Another particularly striking example is Annapolis, Maryland, where the average number of flood days has gone from 3.8 per year in the period between 1957 and 1963 to 39.3 a year in the period between 2007 and 2013. This represents a 925% increase (NOAA, 2014b).

The term "minor" (or "nuisance") flood can be quite misleading, because these flooding events can result in a host of significant hazards. Such floods can render roads impassable, isolating individuals and neighborhoods. Water-covered roads can make it difficult for people to get to important medical appointments, stop individuals from going to pharmacies to obtain medicines, and impede emergency vehicles trying to respond to calls for help. Minor floods can also damage vehicles, homes, and infrastructure (Spanger-Siegfried et al., 2014). Meanwhile, building materials left damp by minor floods provide an excellent environment for the rapid growth of mold. According to public health experts, "the spores of some varieties can begin to germinate in as little as 4 to 12 hours" (Parrot, 2009) and "significant mold growth can occur" within 48 h of materials being exposed to water (Johanning et al., 2014). Depending on the type of mold involved, this can increase the risk of allergy, asthma, and respiratory problems in sensitive populations (Parrot, 2009; EPA, 2016). Finally, in some situations, recurrent flooding may even require people and communities to relocate (Spanger-Siegfried et al., 2014). In short, so-called "minor" flood events can constitute a serious problem with significant public health consequences, particularly as the scope, frequency, and severity of such flooding events increases over time.

If "minor" flooding represents a significant and growing problem, major flood events linked to storms and storm surge can constitute a grave threat. Storm surge is the additional ocean water that is pushed onto shore by a storm (Miles, 2014). It comes on top of whatever water is normally already there. Thus, if an area is experiencing a regular high tide at the time of a storm, the amount of water pushing onto land will be the high tide plus the surge (Miles, 2014). Sea level rise adds another component. When an area has been affected by significant sea level rise, any storm surge that occurs comes on top of the regular tide and on top of the already elevated sea level. The result can be massive, destructive flooding events.

The public health consequences can be serious and widespread. At the most obvious level are deaths due to drowning. Superstorm Sandy provides a powerful illustration. In New York City, the number one direct cause of death from Superstorm Sandy was drowning associated with

the storm surge (Lane et al., 2013). The "majority of deaths occurred in Queens and on Staten Island, and most people perished at the height of the storm, drowned by the surge" (NYT, 2012). According to Sobel (2014), some people drowned in their homes, whereas others perished in vehicles as they tried to escape.

People can also die as a consequence of having to evacuate. Particularly for individuals who are ill, frail, or in care, the process of having to move or be moved can be difficult and traumatic. For some, the result can be premature death. A 2012 study looked at records for more than 36,000 nursing home residents who had experienced Gulf hurricanes (Katrina, Rita, Gustav, and Ike). The analysis concluded that the process of evacuation had compounded morbidity and mortality (Dosa et al., 2012).

Other public health impacts result from the effect of floodwaters on infrastructure. Floodwaters and surge can cause sewers to back up or overflow, collapse or break sewer lines, overtop or engulf sewage treatment facilities, and even completely overwhelm the treatment network. During Superstorm Sandy, for example, "11 billion gallons of sewage flowed into the floodwaters engulfing New York and New Jersey" (Miles, 2014). Floodwaters polluted with human and animal waste can carry high levels of fecal bacteria, which can lead to intestinal and other illnesses (Esworthy, Schierow, Copeland, Luther, & Ramseur, 2006). Rising waters can also damage underground storage tanks, causing hazardous materials to leak into soil, groundwater, and floodwaters and posing a threat to people and the environment (EPA, 2010). Commercial and industrial operations, landfills, and other key facilities can be compromised, potentially releasing biological, chemical, and other contamination into communities (Few & Matthies, 2007).

Flooding events can also affect key healthcare and public health facilities, causing impacts not only to the facilities themselves but impairing the capacity of the system to provide services and assistance to people in affected areas. For example, during Superstorm Sandy, storm surge flooded key radiology facilities at NYU Langone Medical Center. Four MRI scanners, some CT systems and X-ray equipment were destroyed (Knaub, 2013; Godt, 2013). Likewise, at Bellevue Hospital, "millions of gallons of contaminated water pooled in the basement." The morgue flooded, forcing medical personnel to look for other places to keep bodies of the deceased (Miles, 2014, p. 327).

This broad array of potential health impacts makes the sea level rise issue a quintessential public health problem and makes it vital for public health professionals to be involved. The central aim of public health professionals—whether they work for local or state health departments, federal agencies such as the CDC, nongovernmental organizations, laboratories, the hospital and healthcare system, or other agencies—is to "prevent people from getting sick or injured in the first place" (APHA, 2017). Public health responsibilities and initiatives range widely. They include vaccinating children and adults to protect them from serious infectious diseases, programs to reduce tobacco use among young people, efforts to prevent childhood lead poisoning by reducing exposure to lead paint and other sources of lead, monitoring bacteria levels in beach water and issuing swimming advisories, community screening for chronic and communicable diseases/conditions, licensing and inspecting medical and dental X-ray machines and similar devices, and working to ensure the safety of food through such measures as monitoring shellfish for pathogens/toxins and conducting inspections of restaurants and other food establishments (ASTHO Profile, 2017; NACCHO, 2017; Salinsky, 2010; Washington State Department of Health, 2018). Public health also plays a critical role in preparedness and response to health emergencies (Stoto et al., 2005). When foodborne illness outbreaks involving such pathogens as *Escherichia coli*, listeria, and salmonella occur, it is public health epidemiologists, environmental health specialists, laboratorians, and others who track the outbreak, identify the pathogen and the affected foods, and respond to protect members of the public. For example, public health professionals responded to a major, multistate outbreak of *E. coli* O157:H7 infections that killed four children and left hundreds of other people ill, tracing it to consumption of contaminated hamburger patties (MMWR, 1993). Likewise, public health professionals help prepare for, assess, and respond to natural disasters, hazardous materials emergencies, pandemics, terrorism incidents, and ecological disasters (Falk & Ashkenazi, 2012; ASTHO Profile, 2017; NACCHO, 2017; Salinsky, 2010; Washington State Department of Health, 2018). For example, after the Deepwater Horizon disaster in 2010, public health professionals played an important role in assessing chemical air monitoring results, analyzing the safety of

seafood, monitoring the health of cleanup workers and people living in affected communities, and providing health information to the public (see, e.g., Michaels & Howard, 2012; LDHH, 2010, 2012).

The health consequences of sea level rise touch upon many of the aforementioned core concerns, responsibilities and activities of public health professionals. With respect to flooding situations, for example, public health concerns might range from ensuring the safety of food and drinking water supplies after flood events to testing floodwaters for biological, chemical, and other contaminants and from identifying and managing mold problems to assessing the immediate and longer-term health implications of evacuation or relocation. Clearly, then, public health has a critical role to play in helping to protect populations, foster resiliency, and reduce or prevent impacts from sea level rise. As such, it is essential for public health to be "an integral part of current and future sea level rise adaptive planning efforts" (IPP, 2016).

Preparing the Next Generation of Public Health Professionals

To help prepare the next generation of public health professionals to meet the growing health challenges posed by rising seas, a new training initiative was launched in the Hampton Roads region of Southeastern Virginia. Begun in 2015 and continuing to expand today, the effort is being led by Old Dominion University (ODU) in conjunction with Eastern Virginia Medical School (EVMS). The effort incorporates both classroom-based and practice-based activities and includes content on sea level rise and public health in the region and beyond.

The new training initiative grew out of discussions of public health issues that took place through the Hampton Roads Sea Level Rise Preparedness and Resilience Intergovernmental Pilot Project or IPP. Convened at ODU and operating from 2014 to 2016, the IPP's purpose was to bring together a broad range of stakeholders to create a fully comprehensive, integrated approach to sea level rise preparedness and resilience planning in the Hampton Roads region that can also be used as a template for other regions in the United States (IPP, 2015, 2016). Hampton Roads, which has a population of some 1.7 million people, is made up of 17 localities, including the independent cities of Norfolk, Virginia Beach, Chesapeake, Newport News, Hampton, Portsmouth, Suffolk, Poquoson, and Williamsburg. The area has hundreds of historic sites, a long coastline, and beautiful beaches, making it a popular tourist destination.

In addition, the region is one of considerable strategic importance, being home to numerous industries and research facilities, the Port of Virginia (the third biggest U.S. East Coast container port) and a variety of important defense facilities. These include Joint Base Langley-Eustis, Naval Air Station Oceana, Joint Expeditionary Base Little Creek-Fort Story, and Naval Station Norfolk (the largest naval base in the world). The Hampton Roads area and the Chesapeake Bay region more generally are situated at a low land elevation, are undergoing significant subsidence of land, and (like other coastal areas) are experiencing the effects of rising seas (Maryland Sea Grant, 2015). In addition, the city of Norfolk has been identified as one of nine high-risk areas of the North Atlantic Coast in terms of coastal flood risk (NACCS, 2015). Given the region's importance, future sea level rise could have both immediate effects and bigger implications that extend well beyond Hampton Roads.

Employing a "whole of government" and "whole of community" approach, the IPP successfully engaged representatives from a variety of federal agencies, the Commonwealth of Virginia, many localities, elected officials, the Port of Virginia, academia, the Navy, the Coast Guard, the Air Force, the Army Corps of Engineers, private industry (e.g., Newport News Shipbuilding), the legal profession, nongovernmental organizations, infrastructure, vulnerable communities, the real estate community, and other sectors (IPP, 2015, 2016). In 2015, the IPP identified public health as another crucial area needing attention. In April of that year, ODU faculty briefed the IPP Steering Committee on the crucial links between sea level rise and public health. Shortly thereafter, the Steering Committee, by consensus, established a new Public Health Working Group as the fifth working group of the Pilot. (The other four working groups were legal, infrastructure, land use planning, and citizen engagement.) This established public health as a core component of the IPP's work. One significant need identified in discussions with public health professionals was to find new and innovative ways of incorporating sea level rise issues into public health education and training (IPP, 2015, 2016).

Informed and encouraged by the IPP's work, faculty in ODU's School of Community and Environmental

Health moved to create new education and training opportunities for developing public health professionals. The aim: to provide developing public health professionals with a broad understanding of sea level rise and its many public health implications so that they can (1) help identify potential health impacts; (2) contribute to the creation of public health strategies for preventing, reducing, or responding to such impacts; and (3) help to foster more resilient communities.

The new effort centers on the Masters of Public Health (MPH) program. Public health professionals typically gain their foundational professional education and first practical public health training through the multidisciplinary MPH degree. This is where developing public health professionals learn the field and begin to practice it. Thus, the MPH provides an ideal setting in which to incorporate content and activities to enhance public health understanding and readiness for sea level rise.

Although MPH programs can vary, it is typical for the first year in the 2-year degree program to focus on providing foundational knowledge across all areas of public health (including epidemiology, biostatistics, health promotion and health behavior, health policy and health administration, and environmental health). The second year of the degree provides more specialized knowledge (e.g., in such areas as environmental science, toxicology, emergency management, health communication or infectious disease) and an opportunity for real-world application and training.

To ensure that all graduating MPH students—regardless of track or specialty—would be provided with significant knowledge of sea level rise issues, a decision was made to incorporate substantial coverage of sea level rise issues into a first-year core course. The course that was chosen was ODU's foundational course in environmental health that is taken by all MPH students. The three-credit course, entitled Principles of Environmental Health Science, has a typical enrollment of about 60 students per year.

Coverage of sea level rise and public health has been incorporated into the course through a 2-week module. One week introduces the problem of sea level rise and its public health implications. Topics include historical and recent data on global mean sea level rise, sea level rise in relation to the United States, minor flooding, storm surge, direct and indirect health impacts of sea level rise, vulnerable populations, challenges for public health infrastructure and the healthcare system, and implications for public health planning and training.

Students are also provided with the opportunity to consider public health lessons learned from recent flood events. To help illustrate the issues and identify key lessons, students learn from case studies and watch and discuss documentaries. For example, in 2016–2017, students watched two PBS NOVA programs on Superstorm Sandy. NOVA, the award-winning science series on PBS, is produced by WGBH Boston. One of the programs provides extensive information about the effects of storm surge, enabling students to gain a better understanding of the range of issues and impacts (NOVA, 2012). The second program provides information about different approaches for dealing with sea level rise, helping students to consider what changes may be needed to make cities more resilient in the future (NOVA, 2013).

Augmenting the first week of coverage is a second course week that focuses on local sea level rise impacts and issues in relation to public health. Here, noted experts in such areas as oceanography and vulnerability assessment examine flooding patterns in Norfolk and other nearby areas and discuss a range of adaptation, mitigation, and resilience measures. Meanwhile, other modules in the course (e.g., public health emergency preparedness, environmental risk communication) provide opportunities for students to relate sea level rise issues to other aspects of public health. In the second year of the MPH curriculum, students with a continuing interest in the health aspects of sea level rise have the opportunity to reinforce and expand their knowledge through some elective courses that include additional relevant content. For example, in the second-year course entitled Environmental Emergencies and Disasters, students examine historical and recent disaster trends, examine the health implications of community disruption and evacuation, learn more about special populations in disaster, and participate in problem-solving disaster teams.

Whereas the course-based components are intended to provide a basic working knowledge of sea level rise and public health to all MPH students, it is also important for students choosing to focus on this topic to have a way to gain much more in-depth knowledge of the issues as well as practical experience. To achieve this aim, the region's first "community practicum" focusing specifically on sea level rise and health was created in 2015. The 200-h practicum provides students with an in-depth supervised practical public health experience. Under the guidance of an on-site preceptor and an academic adviser, students work on real-world public health issues using the knowledge and skills gained in academic courses.

The first practicum on sea level rise and public health was completed in 2016. MPH student Christine Gumina was based at the IPP, where she worked under the direction of preceptor Emily E. Steinhilber, Assistant Director of Coastal Resilience Research. (The author served as the student's academic advisor.) Ms. Gumina's multipart project involved carrying out an initial review of public health impacts of sea level rise, focusing on a smaller subset of those impacts and relating the findings to the Hampton Roads area. Ms. Gumina also participated in IPP committee and working group meetings, where she interfaced with officials from local, state, and federal agencies, the uniformed services, research institutions, and other organizations (IPP, 2016).

The following year, a second MPH student practicum on sea level rise and health was successfully completed. This second practicum, under the auspices of the Commonwealth Center for Recurrent Flooding Resiliency at ODU, focused on identifying opportunities for increasing public health resilience to sea level rise and recurrent flooding in Hampton Roads. Plans for additional sea level rise practicums are at an advanced stage as of the time of this writing. Meanwhile, since the two interrelated modules on sea level rise and public health were added to the first-year MPH student curriculum, more than 160 students have covered and been examined on the content. This number will continue to grow in the coming years. All will take this knowledge with them as they assume positions in the public health workforce.

Next Steps

Although the new training initiative on sea level rise and public health is still a work in progress, it has already created a solid foundation for expanded efforts in the near future. Next steps include incorporating additional sea level rise content into second-year elective courses, creating an entire MPH level course on sea level rise and public health, and establishing a broader range of sea level practicum sites. Another near-term step involves further developing the training effort's competencies and learning outcomes. The initial set of competencies that guided the launch of the training effort will be expanded and refined using experience gained to date and drawing on input and feedback from sea level rise experts, local and state health departments, and other agencies and stakeholders. Likewise, metrics and evaluation methods will be refined. Taken together, these next steps will help to ensure the continued effectiveness of the training effort.

Conclusion

Global sea level rise has the potential to directly or indirectly affect the health of vast numbers of coastal communities and inhabitants. Thus, in partnership with other fields working to address the issue of sea level rise, public health agencies and professionals have a pivotal role to play in protecting populations, identifying, reducing and preventing impacts, and fostering resilience. The new training initiative in Coastal Virginia—though still in its early stages—is already beginning to help prepare the next generation of public health professionals to meet the challenge.

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References

APHA. 2017. What is Public Health? American Public Health Association. Available at: https://www.apha.org/what-is-public-health (accessed on November 20, 2017).

ASTHO Profile. 2017. 2 ASTHO Profile of State and Territorial Public Health, Volume Four. Arlington, VA: Association of State and Territorial Health Officials.

CDC Foundation. 2017. What is Public Health? The CDC Foundation. Available at: https://www.cdcfoundation.org/what-public-health (accessed on November 20, 2017).

City of Charleston. 2015. Sea Level Rise Strategy. Charleston, South Carolina. Charleston, SC: Author.

Dosa, D., Hyer, K., Thomas, K., Swaminathan, S., Feng, Z., Brown, L., … Mor, V. 2012. To evacuate or shelter in place: implications of universal hurricane evacuation policies on nursing home residents. J Am Med Dir Assoc. 13(2):190.e1–190.e7. https://doi.org/10.1016/j.jamda.2011.07.011.

EPA. 2010. Underground Storage Tank Flood Guide. Solid Waste and Emergency Response, U.S. Environmental Protection Agency. EPA 510-R-10-002.

EPA. 2016. Mold and Health. Last updated on October 19, 2016. Available at: https://www.epa.gov/mold/mold-and-health (accessed on December 14, 2016).

Esworthy, R., Schierow, L-J, Copeland, C., Luther, L., & Ramseur, J.L. 2006. Cleanup after Hurricane Katrina: Environmental Considerations (Report RL33115). Washington, DC: Resources, Science, and Industry Division, Congressional Research Service, Library of Congress. Available at: https://digital.library.unt.edu/ark:/67531/metacrs9025/m1/1/high_res_d/RL33115_2006May03.pdf.

Falk, H., & Ashkenazi, I. 2012. The role of public health. In Cole, L. A., & Connell, N. D. (Eds.), Chapter 10 in Local Planning for Terror and Disaster: From Bioterrorism to Earthquakes. Hoboken, NJ: John Wiley & Sons, Inc. https://doi.org/10.1002/9781118397787.ch10.

Few, R., & Matthies, F. (Eds.) 2007. Flood Hazards and Health: Responding to Present and Future Risks. New York, NY: Earthscan.

Godt, E. 2013. Sandy's wake: Disaster planning re-visited. Health Imaging. Feb 28, 2013. Available at: http://www.healthimaging.com/topics/practice-management/sandy%27s-wake-disaster-planning-re-visited (accessed on February 18, 2018).

IPP. 2015. Phase 1 Report: Accomplishments and Lessons Learned. Hampton Roads Sea Level Rise Preparedness and Resilience Intergovernmental Pilot Project. Norfolk, VA: Old Dominion University.

IPP. 2016. Phase 2 Report: Recommendations, Accomplishments and Lessons Learned. Hampton Roads Sea Level Rise Preparedness and Resilience Intergovernmental Pilot Project. Norfolk, VA: Old Dominion University.

Johanning, E., Auger, P., Morey, P., Yang, C., & Olmsted, E. 2014. Review of health hazards and prevention measures for response and recovery workers and volunteers after natural disasters, flooding, and water damage: mold and dampness. Environ Health Prev Med. 19:93-9. https://doi.org/10.1007/s12199-013-0368-0.

Knaub, J. 2013. Rolling again. Radiology Today. 14(6):22. Available at: http://www.radiologytoday.net/archive/rt0613p22.shtml (accessed on February 12, 2018).

Lane, K., Charles-Guzman, K., Wheeler, K., Abid, Z., Graber, N., & Matte, T. 2013. Health effects of coastal storms and flooding in urban areas: A review and vulnerability assessment. Journal of Environmental and Public Health, Vol. 2013, Article ID 913064. http://dx.doi.org/10.1155/2013/913064.

LDHH. 2010. Oil Spill Health Effect Summary. Week 22 from 05/30/2010 to 06/05/2010. Office of Public Health (OPH) Section of Environmental Epidemiology & Toxicology (SEET), Louisiana Department of Health and Hospitals. Available at: http://ldh.la.gov/assets/docs/SurveillanceReports/OilSpillHealth/_OilSpillSurveillance_2010_01.pdf (accessed on February 15, 2018).

LDHH. 2012. Louisiana Seafood Safety Surveillance Report. Louisiana Department of Health and Hospitals. Available at: http://www.dhh.louisiana.gov/assets/docs/SurveillanceReports/SeafoodSurveillance/2012/SeafoodUpdate_12_14_12.pdf (accessed on February 15, 2018).

Levy, B., & Patz, J. (Eds.) 2015. Climate Change and Public Health. New York, NY: Oxford University Press.

Maryland Sea Grant. 2015. Come High Water: Sea Level Rise and Chesapeake Bay. A Special Report from Chesapeake Quarterly and Bay Journal. Available at: http://www.mdsg.umd.edu/topics/coastal-flooding/rising-sea-level.

McNoldy, B. 2015, October 20. During autumn king tides, nuisance flooding becomes chronic flooding in Miami area. Washington Post. https://www.washingtonpost.com/news/capital-weather-gang/wp/2015/10/20/during-autumn-king-tides-nuisance-flooding-becomes-chronic-flooding-inmiami-area/?utm_term=.971415b63d95. Accessed Dec 8, 2016.

Michaels, D., & Howard, J. 2012. Review of the OSHA-NIOSH Response to the Deepwater Horizon Oil Spill: Protecting the health and safety of cleanup workers. PLOS Currents Disasters. Jul 18, Edition 1. https://doi.org/10.1371/4fa83b7576b6e.

Miles, K. 2014. Superstorm: Nine Days Inside Hurricane Sandy. New York, NY: Dutton.

MMWR. 1993. Update: Multistate outbreak of *Escherichia coli* O157:H7 infections from hamburgers—Western United States, 1992–1993. MMWR-Morbid Mortal W. 42(14):258-63.

NACCHO. 2017. National Profile of Local Health Departments 2016. Washington, DC: National Association of County and City Health Officials.

NACCS. 2015. North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk. Main Report. Final Report. U.S. Army Corps of Engineers. January 2015.

Nerem, R., Beckley, B., Fasullo, J., Hamlington, B., Masters, D., & Mitchum, G. 2018. Climate-change-driven accelerated sea-level rise. P Natl Acad Sci.115(9):2022-5. https://doi.org/10.1073/pnas.1717312115.

New York City Panel on Climate Change. 2015. New York City Panel on Climate Change 2015 Report, executive summary. Ann NY Acad Sci. 1336(1):9-17. https://doi.org/10.1111/nyas.12591.

NOAA. 2014a. Sea Level Rise and Nuisance Flood Frequency Changes around the United States. Technical Report NOS CO-OPS 073. Silver Spring, MD: Author.

NOAA. 2014b. NOAA: Nuisance Flooding an Increasing Problem as Coastal Sea Levels Rise. Study Look at More Than 60 Years of Coastal Water Level and Local Elevation Data Changes. Silver Spring, MD: Author. Available at: http://www.noaanews.noaa.gov/stories2014/20140728_nuisanceflooding.html.

NOAA. 2017a. Is Sea Level Rising? Silver Spring, MD: Author. Available at: https://oceanservice.noaa.gov/facts/sealevel.html (accessed on November 21, 2017).

NOAA. 2017b. What Percentage of the American Population Lives Near the Coast? Silver Spring, MD: Author. Available at: https://oceanservice.noaa.gov/facts/population.html (accessed on November 21, 2017).

NOVA. 2012. Inside the Megastorm. Dragonfly Film and Television Productions Ltd for NOVA/WGBH in association with the BBC. PBS Airdate: November 18, 2012. PBS Dragonfly Film and Television Productions Ltd and WGBH Educational Foundation.

NOVA. 2013. Megastorm Aftermath. A NOVA Production by Miles O'Brien Productions, LLC, for WGBH Boston. PBS Airdate: October 9, 2013. WGBH Educational Foundation.

NYT. 2012. Mapping Hurricane Sandy's deadly toll. New York Times, N.Y./Region. November 17, 2012. Available at http://www.nytimes.com/interactive/2012/11/17/nyregion/hurricane-sandy-map.html (accessed October 23, 2016).

Parrot, K. 2009. Mold Basics. Virginia Cooperative Extension. Publication 2901–7019. Available at: https://pubs.ext.vt.edu/2901/2901-7019/2901-7019_pdf.pdf (accessed September 2016).

Salinsky, E. 2010. Governmental public health: An overview of state and local public health agencies. National Health Policy Forum. Background Paper Number 77. Washington, DC: The George Washington University.

Sobel, A. 2014. Storm Surge: Hurricane Sandy, Our Changing Climate, and Extreme Weather of the Past and Future. New York, NY: Harper Collins.

Spanger-Siegfried, E., Fitzpatrick, M., & Dahl, K. 2014. Encroaching Tides: How Sea Level Rise and Tidal Flooding Threaten U.S. East and Gulf Coast Communities over the Next 30 Years. Cambridge, MA: Union of Concerned Scientists.

Stoto, M., Dausey, D., Davis, L., Leuschner, K., Lurie, N., Myers, S., … Wasserman, J. 2005. Learning From Experience: The Public Health Response to West Nile Virus, SARS, Monkeypox, and Hepatitis A Outbreaks in the United States. Santa Monica, CA: RAND Corporation.

UN. 2016. UN Atlas of the Oceans. Human Settlements on the Coast. UN-OCEANS. United Nations. Available at: http://www.oceansatlas.org/subtopic/en/c/114/ (accessed on November 21, 2017).

Washington State Department of Health. 2018. Community and Environment. Available at: https://www.doh.wa.gov/CommunityandEnvironment (accessed on February 13, 2018).